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Atlantic Menhaden, *Brevoortia tyrannus*, Purse Seine Fishery, 1972-84, with a Brief Discussion of Age and Size Composition of the Landings

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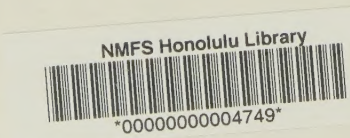

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CONTENTS

Introduction 1

Changes in sampling and reporting procedures 1

Changes in the fishery 4

Total landings, vessels, effort, and CPUE in the fishery 5

Landings, age composition, effort, and CPUE by area 6
- North Atlantic 6
- Middle Atlantic and Chesapeake Bay 7
- South Atlantic 8
- North Carolina fall fishery 9

Length and weight statistics 10

Summary 11

Acknowledgments 15

Citations 15

Appendix Tables 16

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Joseph W. Smith
William R. Nicholson
Douglas S. Vaughan
Donnie L. Dudley
Ethel A. Hall
Beaufort Laboratory
Southeast Fisheries Center
National Marine Fisheries Service, NOAA
Beaufort, North Carolina 28516-9722

ABSTRACT

This report summarizes (1) annual purse seine landings of Atlantic menhaden, *Brevoortia tyrannus*, for 1972-84, (2) estimated numbers of fish caught by fishing area, (3) estimates of nominal fishing effort and catch-per-unit-effort, (4) mean fish length and weight, and (5) major changes in the fishery. During the 1970s stock size and recruitment increased and the age composition broadened, reversing trends witnessed during the fishery's decline in the 1960s. Landings steadily improved and by 1980 the total coastwide landings exceeded 400,000 metric tons. Nevertheless, the character of the fishery changed considerably. Eleven reduction plants processed fish at seven ports in 1972, but in 1984 only eight plants operated at five ports. Beginning in the mid-1960s the center of fishing activity shifted from the Middle Atlantic area to the Chesapeake Bay area, which has continued to dominate the fishery in landings and effort through the 1970s and 1980s. During this period the average size and age of fish in the catches declined.

Introduction

The purse seine fishery for Atlantic menhaden had its origins in coastal New England waters during the 1800s. Fishing techniques and processing methods gradually improved and by the 1930s the fishery spread south to the Middle and South Atlantic states (Nicholson 1971a). Early in the evolution of the fishery the principal product was fish scrap used for fertilizer. After World War II the demand for fish meal and fish oil increased, and the industry underwent significant modernization. Major innovations included spotter aircraft, nylon purse seines, hydraulic power blocks, aluminum purse boats, and large catcher vessels (>300 net tons) with refrigerated fish holds (Nicholson 1971a). The industry grew rapidly and peak landings occurred in 1956. Presently almost all purse seine landings are processed at reduction plants into three major products: fish meal and fish solubles used as supplements in poultry feed, and fish oil used primarily as a refined edible oil in Europe and Canada. Recently, a small but increasing portion of the landings have been frozen for crab bait.

Since 1955 the Beaufort Laboratory of the National Marine Fisheries Service (formerly the Bureau of Commercial Fisheries until 1970) has monitored the Atlantic menhaden purse seine fishery for biostatistical and catch-and-effort data. Summary reports dealing with this fishery are available for the years 1952-55 (June and Reintjes 1959), 1956 (June and Reintjes 1960), 1957 (June 1961), 1958 (June and Nicholson 1964), 1959-62 (Nicholson and Higham 1964a,b, 1965, 1966), and 1963-71 (Nicholson 1975).

The purposes of this paper are to update routine biostatistical and catch-and-effort data collected by the Beaufort Laboratory from the Atlantic menhaden purse seine fishery during 1972-84, to discuss age and size composition of the catches, to document major changes in the fishery, and to serve as a supportive document for stock assessment analyses (Vaughan and Smith 1986a). Included are (1) annual purse seine landings of Atlantic menhaden for ports from Maine to Florida; (2) estimated numbers of fish caught in each of the five fishing areas; (3) estimated nominal fishing effort and catch-per-unit-effort by area of vessel origin; and (4) mean fish lengths and weights by fishing area, season, and age.

Changes in Sampling and Reporting Procedures

Significant changes have occurred in sampling and reporting procedures since the report of Nicholson (1975). Prior to 1972, menhaden port samplers were instructed to weigh (in grams), measure (fork length in mm), remove scales for ageing, and sex 20 fish randomly chosen from a sampling bucket and taken from the top of the hold from each menhaden vessel sampled. Since 1972 only 10 randomly chosen fish per collection were weighed, measured, and had scales removed (fish no longer sexed), as it has been recognized that a 10-fish sample provides an adequate representation of a random sample from the vessel's last purse seine set (Chester 1984). With the increased importance of Chesapeake Bay and North Carolina landings to the total, we increased sampling activity at these sites by adding a second port sampler in the early 1980s during months of peak landings (Table 1).

For the purposes of summary and analysis, the Atlantic coast was divided into four geographic fishing areas and one temporal fishing area by June and Reintjes (1959), with one minor change in the boundary between the Chesapeake Bay and South Atlantic areas of Nicholson (1975) (Fig. 1). The North Carolina fall fishery constitutes the temporal fishing area and exploits fish from about

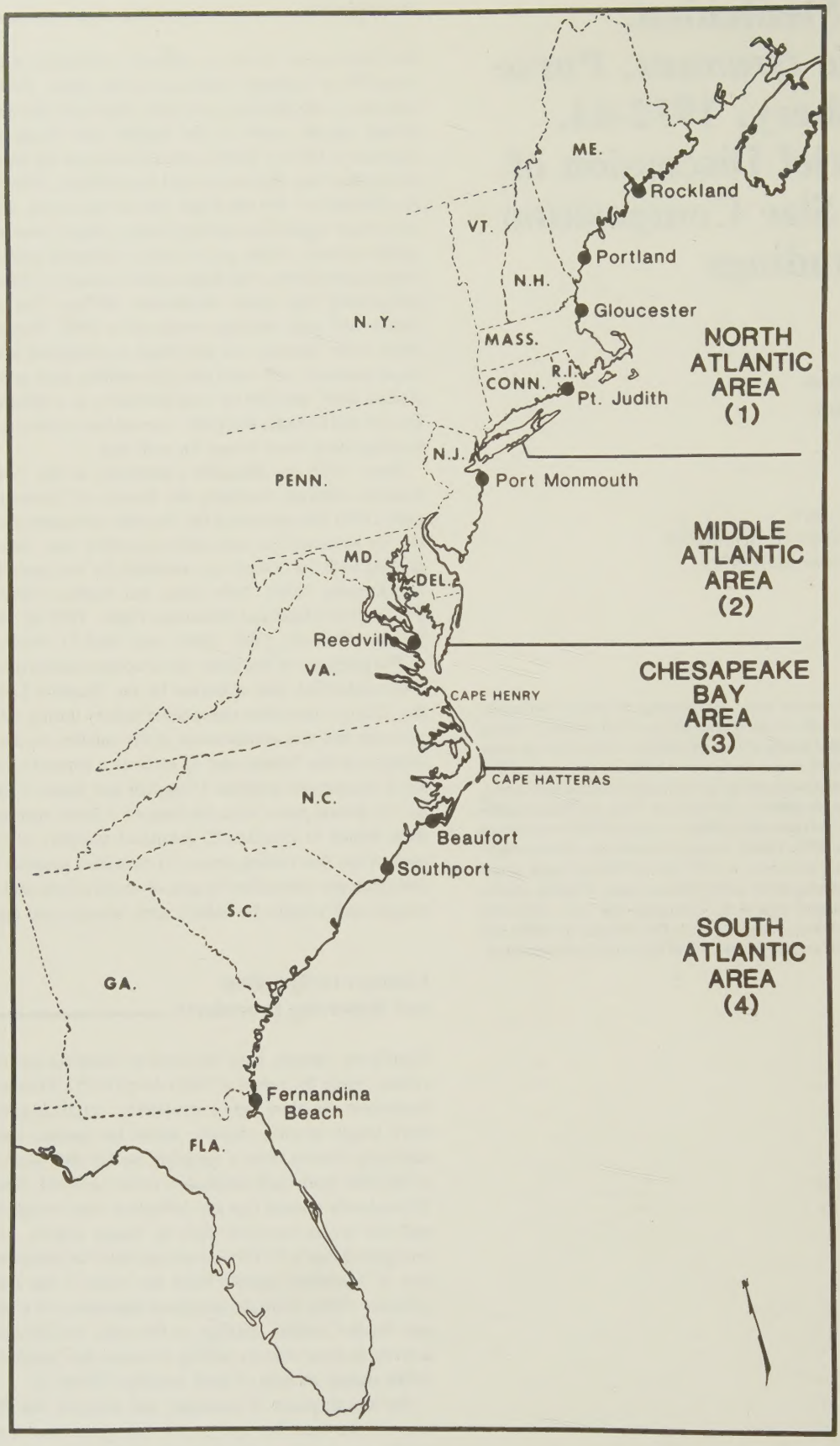

Figure 1

Location of fishing areas and plants, Atlantic menhaden purse seine fishery, 1972-84.

Table 1

Number of 10-fish samples collected from Atlantic menhaden purse seine catches by fishing area, port, and plant, 1972-84.

Location	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
NORTH ATLANTIC AREA													
Rockland, ME	*	*	*	0	5	2	0	0	0	4	3	11	62
Portland, ME	*	1	*	0	*	0	7	0	0	0	2	6	*
Gloucester, MA	0	6	20	21	18	30	64	66	66	100	60	95	171
Point Judith, RI	6	2	13	14	18	15	15	9	*	*	0	*	*
MIDDLE ATLANTIC AREA													
Port Monmouth, NJ	47	59	67	133	125	171	116	92	109	115	*	*	*
CHESAPEAKE BAY AREA													
Reedville, VA	0	*	*	*	*	*	*	*	*	*	*	*	*
(3 plants)	170	191	111	125	108	110	108	97	84	170	243	270	266
	306	228	125	124	132	158	137	133	137	164	233	338	301
SOUTH ATLANTIC AREA													
Beaufort, NC	27	89	97	103	89	74	53	64	114	158	139	205	191
(3 plants)	7	2	11	45	22	33	41	42	32	27	28	59	55
	10	0	53	66	41	50	48	53	43	37	59	94	78
Southport, NC	13	32	40	53	63	49	63	42	27	66	88	29	*
Fernandina Beach, FL	70	26	6	43	26	32	59	39	119	80	52	42	45
Totals	656	636	543	727	647	724	711	637	731	921	907	1,149	1,169

*Plant did not operate.

Cape Hatteras south to the southern border of North Carolina. This fishery usually begins in late October or early November, depending upon the arrival of migratory menhaden from waters farther north, and ends the last day of February of the next calender year (although most fishing activity usually stops by mid-January). For standardized data summary, the first week of the fall fishery is taken to be the week which ends between 8 and 14 November.

Vessels rarely fished in areas other than where their home port and processing plant were located (Table 2). Exceptions included vessels from the plant at Port Monmouth, NJ (Middle Atlantic area) which frequently fished in Long Island Sound (North Atlantic area), and vessels from plants in Chesapeake Bay which in 1983-84 tended to fish more often in areas north of the Chesapeake Bay area and also in the South Atlantic area during November and December. Vessels from the South Atlantic area rarely fished in areas to the north.

Estimated numbers of fish are calculated as described in Chester (1984). However, unlike previous summary reports for Atlantic menhaden, we report the estimated numbers of fish by area *caught* rather than by area *landed*. The former is biogeographically more realistic, and better serves our purpose of providing a supportive document for population modeling and stock assessment analyses (Vaughan and Smith 1986a). Furthermore, recent state management options developed for the Atlantic menhaden fishery (Vaughan and Smith 1986b) were devised based on area of capture. In this light, Table 3 shows tonnage of fish by area landed, and from a historical perspective serves the concerns of state fisheries managers and menhaden industry personnel. Estimates of number of fish by area caught (Tables 8-12) were not derived directly from tonnages in Table 3, but rather from the proportion of sampled fish caught by fishing area as computed via our sampling program.

In this report we use the term "landings" to refer to (1) the total weight of fish (in metric tons) offloaded at a plant (or plants), or (2) the coastwide estimate of total number of fish harvested and offloaded at dockside. We use the terms "catch" or "area caught" in reference to estimates of number of fish caught in a given fishing area. In a sense, our use of the term "catch-per-unit-effort (CPUE)" is a misnomer, because in this report CPUE is actually "landings-per-unit-effort" defined as metric tons of fish landed per vessel week[1].

Historic port sampling data for size and age were re-examined for errors using recently developed editing programs on the computer; corrections were made to the data set where appropriate. Hence, estimated numbers of fish caught at age for 1970-84 (Tables 4 and 8-12) may differ slightly with numbers reported by Nicholson (1975) and those in ASMFC (1981). Estimated numbers-at-age for years prior to 1970 are from two sources: 1965-69, estimated numbers by area caught are from the data set

[1]A vessel week is one vessel fishing at least one day of one week.

Table 2

Percentages of Atlantic menhaden (estimated numbers of fish) caught by purse seine vessels in areas other than where their home ports were located.

Year	North Atlantic	Middle Atlantic	Chesapeake Bay
1972	0.0	14.7	5.1
1973	0.0	21.3	2.4
1974	0.0	17.2	13.0
1975	0.0	54.8	10.8
1976	0.0	26.7	15.2
1977	0.0	20.7	9.3
1978	0.0	58.7	8.8
1979	0.0	48.6	0.6
1980	0.0	59.4	0.0
1981	0.0	62.6	3.1
1982	0.0	*	3.2
1983	0.0	*	20.0
1984	0.0	*	20.1

*Plant did not operate.

Table 3
Atlantic menhaden purse seine landings (10^3 metric tons) by area landed, 1940-84.

Year	North Atlantic	Middle Atlantic	Chesapeake Bay	South Atlantic	North Carolina fall fishery	Total
1940	16.8	91.1	35.3	37.9	36.6	217.7
1941	33.5	104.1	60.2	45.2	34.9	277.9
1942	14.6	77.7	21.9	32.9	20.1	167.2
1943	9.8	96.8	42.1	59.7	28.8	237.2
1944	27.5	122.6	32.2	46.9	28.7	257.9
1945	34.0	136.4	35.1	58.5	31.9	295.9
1946	42.9	183.8	57.6	40.8	37.3	362.4
1947	44.2	185.8	81.2	34.2	32.9	378.3
1948	44.4	137.4	68.3	55.8	40.6	346.5
1949	52.2	149.8	62.8	59.3	39.7	363.8
1950	49.3	143.0	63.1	20.0	21.8	297.2
1951	51.0	168.6	56.1	54.6	31.1	361.4
1952	58.1	193.7	45.7	86.0	26.4	409.9
1953	59.7	363.2	77.8	52.8	39.7	593.2
1954	64.9	335.7	126.0	39.6	41.9	608.1
1955	83.3	317.6	132.7	43.4	64.4	641.4
1956	98.5	378.3	94.0	68.6	73.7	712.1
1957	83.5	304.5	126.0	36.4	52.0	602.8
1958	36.0	211.1	151.3	41.3	70.3	510.0
1959	66.0	250.9	196.8	63.1	82.3	659.1
1960	66.4	256.0	108.5	36.7	62.2	529.8
1961	58.6	274.6	128.7	44.1	69.9	575.9
1962	64.7	249.9	155.1	42.2	25.8	537.7
1963	35.2	111.7	104.0	34.2	61.8	346.9
1964	15.0	35.2	134.1	46.5	38.4	269.2
1965	11.9	45.8	126.1	36.7	52.9	273.4
1966	1.8	6.0	115.6	24.5	71.7	219.6
1967	0.0	17.1	91.1	34.1	51.2	193.5
1968	6.7	26.2	115.5	33.6	52.8	234.8
1969	2.9	12.5	72.0	32.9	41.3	161.6
1970	4.3	11.4	182.9	42.4	18.3	259.4
1971	10.4	23.0	170.7	38.3	7.9	250.3
1972	14.5	54.6	245.5	45.9	5.4	365.9
1973	29.9	277.4	*	37.2	2.4	346.9
1974	35.8	194.8		45.9	15.7	292.2
1975	23.1	149.8		59.5	17.8	250.2
1976	28.4	243.3		50.7	18.1	340.5
1977	15.0	244.1		49.8	32.2	341.1
1978	31.4	214.1		60.3	38.2	344.1
1979	29.4	230.7		61.6	54.0	375.7
1980	29.7	282.8		53.2	35.8	401.5
1981	21.8	215.9		79.1	64.5	381.3
1982	293.1		*	58.8	30.5	382.4
1983	318.9			31.3	68.4	418.6
1984	238.6			19.0	68.7	326.3

*Landings from two areas combined to protect confidential data.

used by Ahrenholz et al. (1987); 1955-64, estimated numbers-at-age are available only by area landed and are from Nicholson (1975).

Appendix formats used by Nicholson (1975) which featured length-frequency distributions for sampled fish by port and age, and mean lengths of sampled fish by month and age, were consolidated and refined. In Appendix Tables 2-13 we report simple mean lengths and simple mean weights by fishing area (and coastwide), age (in yr), and season. Appendix Table 1 defines seasons (= quarters) used in subsequent appendices. Coastwide estimates of numbers of fish landed by age and quarter for 1965-84 that were used in stock assessment analyses (Vaughan and Smith 1986a) are given in Appendix Table 14.

Changes in the Fishery

As documented by Nicholson (1975), the purse seine fishery for Atlantic menhaden declined through the 1960s when fish became scarce in the northern half of their range. Stock size decreased due to low recruitment and the age structure became truncated (Ahrenholz et al. 1987). Plants closed and the vessels reduced their fishing north of Chesapeake Bay. During the mid-1960s landings and CPUE at plants in Chesapeake Bay declined even as effort increased. South of Cape Hatteras, the fishery was relatively small and there was little change. During the 1970s recruitment levels increased and by the latter part of the decade the age structure began to broaden (Ahrenholz et al. 1987). Nevertheless, the character of the fishery changed considerably during the 1970s. Eleven reduction plants operated at seven ports in 1972, but in 1984 only eight plants processed fish at five ports.

Plants in the North Atlantic area primarily process fish offal from the New England trawl fisheries, but they process menhaden during summer and early fall when the fish are available locally. Most vessels fishing for North Atlantic plants are trawlers that convert to purse seine fishing during summer. In 1972 only two plants (Pt. Judith, RI, and Gloucester, MA) were active in the North Atlantic area (Fig. 1). In 1975 three facilities processed menhaden (Gloucester, MA, Portland, ME, and Rockland, ME), and although purse seine vessels continued to land menhaden at Pt. Judith, the reduction plant had closed and the fish were transported via truck to the facility at Portland for processing. Landings at Pt. Judith were handled in this manner through 1979 and again in 1982. After 1983 the plant at Portland closed. In 1984 only the facilities at Gloucester and Rockland processed menhaden. Closure of the plants at Pt. Judith and Portland was not related directly to a scarcity of menhaden, rather it was primarily due to local factory-odor abatement problems. In 1984 the plant at Gloucester came under similar scrutiny and was inactive during 1985 and 1986.

During the 1950s and early 1960s as many as five reduction plants were active in the Middle Atlantic area, but through the 1970s only one plant at Port Monmouth, NJ, was active. It ceased operation after the 1981 fishing season. During the late 1960s and early 1970s acquisitions and consolidation reduced the number of operating factories in the Chesapeake Bay area (Nicholson 1975). By 1973 only two processing plants remained in the Chesapeake Bay area; both were in Reedville, VA, and both were active through 1985. One of these temporarily suspended operations after the 1985 fishing season. During the mid-1960s plants in Chesapeake Bay acquired larger and faster vessels, and the fishing season was extended into November as migratory schools of fish were exploited off the Virginia capes (Nicholson 1975). This trend continued through the 1980s with Virginia plants processing fish into December in 8 of 13 years between 1972 and 1984. In some years (1980s) migratory fish harvested as far south as Cape Hatteras, NC, were processed in Virginia. Moreover, beginning in 1983 vessels from Chesapeake Bay caught significant numbers of fish (Table 2) in the Middle Atlantic and North Atlantic areas, left vacant after the plant at Port Monmouth closed in 1981. Thus, by the mid-1980s vessels from Chesapeake Bay exploited Atlantic menhaden in all four geographical fishing areas.

In the South Atlantic area, the number of processing plants remained relatively stable from 1972 to 1984. Two plants in Beaufort, NC, operated during all years of the period in both the

"summer" fishery[2] and the North Carolina fall fishery. A third plant in Beaufort operated during the summer fishery of 1972, 1973, 1975, and 1978-80, and during each North Carolina fall fishery, 1972-84; this plant was inactive during 1985 and 1986. One plant in Southport, NC, was active during the summer fishery, 1972-83, and during the North Carolina fall fishery of 1975, 1977, 1978, and 1980-83. It closed after the 1983 fishing season. The single plant in Fernandina Beach, FL, was active during all years, 1972-1984.

Total Landings, Vessels, Effort, and CPUE in the Fishery

Total landings of Atlantic menhaden declined precipitously during the 1960s, falling from 575,900 metric tons in 1961 to 161,600 mt in 1969 (Table 3). Landings gradually increased through the early 1970s, yet fluctuated between 250,200 mt in 1975 and 365,900 mt in 1972. During the late 1970s landings remained above the 340,000 mt level and continued to climb. By 1980, 401,500 mt were landed and the landings of 418,600 mt in 1983 were the greatest since 1962.

During the 1960s the estimated number of fish in the coastwide landings declined to a low of 868.18 million fish in 1969 (Table 4). As landings improved through the early 1970s, estimated numbers of fish landed ranged from 969.1 million in 1971 to 1,990.6 million in 1974. Estimated total numbers of fish exceeded 3,000 million in 1976 and remained above this level through 1984. Our estimate of 3,984.0 million fish landed in 1981 was the greatest since 1959.

Although estimated numbers of fish in the landings during 1976-84 approached, and even surpassed in some years, the estimates of the 1950s, the age composition of the landings during the late 1970s and early 1980s changed considerably (Table 4). The fishery has always relied heavily on prespawning fish (age 2 and younger) (Table 4). Prior to the population decline in the early 1960s, the annual percentage of prespawners in the total landings averaged 83% between 1955-62 (range: 51-96%). Over the period 1975-84 greater numbers of prespawners were taken and their annual percentage in the total landings was 94% (range: 87-98%). Notewor-

[2]The summer fishery in the South Atlantic area traditionally refers to the fishery from April through early November, after which time migratory schools of fish from more northerly latitudes begin to appear in North Carolina coastal waters.

Table 4

Estimated numbers (10^6) of Atlantic menhaden by age caught by purse seine vessels, 1955-84.

	Age (yr)									
Year	0	1	2	3	4	5	6	7	8-10	Total
1955	761.01	674.15	1,057.68	267.31	307.21	38.07	10.53	1.84	0.64	3,118.44
1956	36.37	2,073.26	902.72	319.60	44.78	150.68	28.70	6.72	1.99	3,564.82
1957	299.58	1,599.98	1,361.77	96.73	70.80	40.52	36.93	4.26	1.10	3,511.67
1958	106.06	858.16	1,635.35	72.05	17.25	15.94	9.09	4.88	0.43	2,719.21
1959	11.40	4,038.72	851.29	388.27	33.41	11.87	12.36	4.55	1.77	5,353.64
1960	72.17	281.01	2,208.63	76.37	102.20	23.77	7.95	2.36	0.65	2,775.11
1961	0.25	832.42	503.60	1,209.57	19.18	29.38	2.86	.81	0.24	2,598.31
1962	51.58	514.11	834.52	217.25	423.37	30.75	24.60	2.98	0.70	2,099.86
1963	96.89	724.23	709.20	122.53	44.97	52.38	10.42	3.33	0.56	1,764.51
1964*	302.59	703.95	604.98	83.50	17.94	7.85	6.62	1.31	0.32	1,729.06
1965	249.12	745.21	421.40	77.76	12.17	1.81	1.22	0.75	0.06	1,509.48
1966	349.45	550.82	404.14	31.70	3.89	0.36	0.11	0.11	0.04	1,340.61
1967	6.95	633.20	265.67	72.77	5.09	0.49	0.01	—	—	984.18
1968	154.26	377.36	538.95	65.69	10.67	0.98	0.06	—	—	1,147.98
1969**	158.13	372.33	284.31	47.81	5.44	0.15	0.01	—	—	868.18
1970	21.42	870.85	473.92	32.63	4.02	0.11	—	—	—	1,402.96
1971	72.85	263.29	524.32	88.29	17.84	2.51	—	—	—	969.10
1972	50.16	981.27	488.47	173.06	19.12	1.86	—	—	—	1,713.95
1973	55.98	588.47	1,152.94	38.63	7.00	0.34	—	—	—	1,843.36
1974	315.55	636.68	985.97	48.59	2.49	1.35	—	—	—	1,990.63
1975	298.64	719.96	1,086.53	50.24	6.63	0.20	0.10	—	—	2,162.30
1976	274.23	1,611.96	1,341.09	47.97	7.95	0.28	—	—	—	3,283.47
1977	484.62	1,004.54	2,081.77	83.46	17.80	1.41	0.11	—	—	3,673.71
1978	457.41	664.09	1,670.91	258.12	31.19	3.48	—	—	—	3,085.20
1979	1,492.46	623.14	1,603.29	127.93	21.76	1.47	0.09	—	—	3,870.13
1980	88.29	1,478.06	1,458.23	222.71	69.23	14.36	1.44	—	—	3,332.32
1981	1,187.57	698.66	1,811.46	222.20	47.47	15.37	1.27	—	—	3,984.02
1982	114.11	919.44	1,739.55	379.67	16.33	5.78	0.53	0.32	—	3,175.72
1983	964.41	517.22	2,293.06	114.35	47.37	5.01	0.23	—	0.46	3,942.11
1984	1,294.22	1,024.17	892.09	271.50	50.34	15.21	0.51	—	—	3,548.04

*1955-64 data from Nicholson (1975).

**1965-69 data from database used by Ahrenholz et al. (1987).

thy were the large numbers of age-0 menhaden (i.e., "peanuts") caught during 1974, 1979, 1981, 1983, and 1984, most of which were taken during the North Carolina fall fishery.

Total number of vessels in the fishery fell from 150 vessels in 1955 to 51 vessels in the early 1970s (Table 5). Vessel numbers increased slightly during the mid-1970s to 64, then declined further to 38 vessels in 1984.

Since the mid-1950s to early 1960s when nominal effort expended by the fleet averaged over 2,000 vessel weeks per year, the general trend in nominal effort has been one of decline (Table 6). On the other hand, effective effort[3] has probably increased, as modern vessels are much more efficient than their earlier counterparts, owing in part to faster steel-hull vessels with greater refrigerated hold capacities and better coordination among vessels and spotter aircraft. This has allowed for increased time spent fishing.

[3]In the Atlantic menhaden fishery, observed or nominal fishing effort cannot be directly adjusted to units of effective effort (effort that is a more reliable measure of fishing mortality) for reasons outlined by Nicholson (1971a) and Schaaf and Huntsman (1972).

Table 5

Numbers of purse seine vessels that landed Atlantic menhaden during the fishing season by area of vessel origin, 1955-84.

Fishing season	Total[1]	North Atlantic[2]	Middle Atlantic	Chesapeake Bay[3]	South Atlantic[4]	NC fall fishery
1955	150	39	48	20	34	51
1956	149	40	47	24	30	63
1957	144	33	46	25	31	64
1958	130	23	44	28	26	63
1959	144	34	45	31	25	59
1960	115	19	47	22	20	37
1961	117	21	47	23	20	44
1962	112	20	47	29	15	49
1963	112	10	46	36	16	46
1964	111	9	37	38	16	51
1965	84	6	13	38	19	46
1966	76	5	10	36	16	43
1967	64	0	4	32	16	46
1968	59	2	4	25	16	45
1969	51	3	4	22	16	36
1970	54	4	1	18	11	37
1971	51	5	2	20	11	32
1972	51	9	4	19	11	5
1973	58	10	6	23	11	4
1974	63	12	6	22	12	12
1975	61	9	5	22	14	17
1976	62	12	4	21	12	13
1977	64	12	5	24	10	16
1978	53	13	5	22	11	18
1979	54	11	4	22	13	18
1980[5]	51	5	6	24	12	19
1981	57	8	7	23	13	19
1982	47	9	0	22	8	18
1983	41	7	0	24	10	17
1984	38	6	0	26	6	12

[1]Includes all vessels that landed fish during the year. Within a year, the sum of vessels across all areas does not equal the total because numerous vessels that participated in the summer fishery in Chesapeake Bay also fished from the port of Beaufort, NC, during the North Carolina fall fishery.

[2]Vessels fishing from New England ports in recent years are mostly trawlers that convert to purse seiners in summer. Some fish regularly and others fish sporadically.

[3]Includes vessels that fished only in the summer fishery. Does not include vessels added in October or November.

[4]Includes only vessels that landed regularly in the summer fishery.

[5]1955-80 data from ASMFC (1981).

Given these improvements, the fishing power of the modern fleet has probably more than doubled (Ahrenholz et al. 1987).

Catch-per-unit-effort trends in Chesapeake Bay and areas north showed general declines through the 1960s, with improvement through the 1970s and early 1980s (Table 7). South of Chesapeake Bay dramatic declines in CPUE were not apparent during the 1960s, and CPUE tended to increase during the 1970s and early 1980s.

Landings, Age Composition, Effort, and CPUE by Area

North Atlantic

For the period 1955-62 annual landings in the North Atlantic area averaged 11% of the total annual landings for the entire fishery (Table 3). Landings declined through the 1960s and as the population recovered in the 1970s the North Atlantic area again contributed significantly to the total landings. Between 1972 and 1981[4] annual North Atlantic landings averaged about 8% of the total fishery.

The purse seine fishery for Atlantic menhaden in the North Atlantic area is comprised almost exclusively of age-2 fish and older, with ages 2 and 3 predominating (Table 8). During the

[4]North Atlantic area landings for 1982-84 are combined with other areas to protect landings confidentiality.

Table 6

Atlantic menhaden nominal fishing effort (vessel weeks) by area of vessel origin, 1955-84.

Year	North Atlantic	Middle Atlantic	Chesapeake Bay	South Atlantic	NC fall fishery	Coastwide
1955	526	1,018	454	488	262	2,748
1956	564	979	487	563	285	2,878
1957	431	1,094	552	469	229	2,775
1958	268	821	578	397	279	2,343
1959	413	980	685	518	251	2,847
1960	321	906	416	286	168	2,097
1961	292	1,018	482	396	183	2,371
1962	322	1,035	581	310	103	2,351
1963	265	874	676	276	240	2,331
1964	143	381	806	292	185	1,807
1965	96	302	838	361	208	1,805
1966	41	89	809	269	178	1,386
1967	0	126	781	241	168	1,316
1968	28	122	636	255	168	1,209
1969	39	116	523	173	144	995
1970	30	62	536	177	101	906
1971*	87	79	512	180	39	897
1972	89	101	564	199	20	973
1973	138	116	629	203	13	1,099
1974	152	127	589	238	39	1,145
1975	146	95	616	287	74	1,218
1976	142	123	570	254	74	1,163
1977	117	131	663	216	112	1,239
1978	110	90	614	274	122	1,210
1979	98	95	589	274	142	1,198
1980	67	128	636	231	96	1,158
1981	83	137	545	239	129	1,133
1982	135	0	535	207	71	948
1983	103	0	600	147	145	995
1984	100	0	570	96	126	892

*1955-71 data do not agree with Nicholson (1975) because he adjusted (reduced) effort in the North Atlantic area, and to some extent areas farther south, to compensate for the small size of vessels that frequently fished in those areas. Present values are unadjusted estimates of nominal fishing effort.

Table 7
Catch-per-unit-effort data (metric tons/vessel week) for the Atlantic menhaden purse seine fishery, 1955-84.

	North Atlantic	Middle Atlantic	Chesapeake Bay	South Atlantic	NC fall fishery
1955	158	312	292	89	246
1956	175	386	193	122	259
1957	194	278	228	78	227
1958	134	257	262	104	252
1959	160	256	287	122	328
1960	207	283	261	128	370
1961	201	270	267	111	382
1962	201	241	267	136	250
1963	133	128	154	124	258
1964	105	92	166	159	208
1965	124	152	150	102	254
1966	44	67	143	91	403
1967	0	136	117	141	305
1968	239	215	182	132	314
1969	74	108	138	190	287
1970	143	184	341	240	181
1971	120	291	333	213	203
1972	163	541	435	231	270
1973	217	372	*	183	185
1974	236	272		193	403
1975	158	211		207	241
1976	200	351		200	245
1977	128	307		231	288
1978	285	304		220	313
1979	300	337		225	380
1980	443	370		230	373
1981	263	317		331	500
1982	437		*	284	430
1983	454			213	472
1984	356			198	545

*CPUE data from two areas combined to protect confidential landings.

1960s estimated numbers of fish caught fell from 130.7 million in 1962 to zero effort and no landings in 1967[5]. Through the early 1970s increasing numbers of age-2 and -3 fish were captured and by 1980 and 1981 age-4 and -5 fish also made significant contributions to the North Atlantic catch. By the late 1970s annual estimates of total numbers of menhaden caught in the North Atlantic area approached pre-1963 levels.

The number of active purse seine vessels in the North Atlantic area increased through the 1970s to 13 by 1978, but pre-1963 levels of participation in the fishery were not attained (Table 5). The numbers of vessels declined in the 1980s and in 1984 only six vessels fished out of two ports (Gloucester and Rockland). Effort in the North Atlantic area increased during the 1970s to 152 vessel weeks in 1974, but then fluctuated between 67 vessel weeks in 1980 to 146 vessel weeks in 1975 (Table 6). During the mid-1970s CPUE levels in the North Atlantic area ranged from 128 mt/vessel week in 1977 to 236 mt/vessel week in 1974 (Table 7). CPUE gradually increased through the late 1970s and reached 443 mt/vessel week in 1980. CPUE levels greater than 250 mt/vessel week were maintained through 1984.[6]

[5]Although no menhaden were landed for reduction at North Atlantic ports in 1967, an estimated 3.3 million fish were caught in the North Atlantic area (Table 8), but were landed in either the Middle Atlantic or Chesapeake Bay areas.

[6]CPUE values for Middle Atlantic and Chesapeake Bay areas for 1972-81 have been combined to protect landings confidentiality. Likewise, CPUE values for the North Atlantic and Chesapeake Bay areas for 1982-84 have also been combined.

Middle Atlantic and Chesapeake Bay

Between 1973 and 1981 only one plant operated in the Middle Atlantic area and only two plants operated in Chesapeake Bay; therefore, a discussion of Atlantic menhaden landings from these areas, 1973-81, requires that actual landings information be combined to protect confidential data. Furthermore, after 1981 the facility in New Jersey closed, hence the Chesapeake Bay area landings for 1982-84 were necessarily combined with North Atlantic area landings, again for reasons of confidentiality.

Prior to 1962, annual landings of Atlantic menhaden in the Middle Atlantic area surpassed those of the Chesapeake Bay area, often more than twofold (1955-57, 1960, 1961) (Table 3). Between 1955 and 1962 annual Middle Atlantic area landings averaged 67% of the total from both areas combined. Landings for both areas declined sharply in the 1960s, low values being 6,000 mt for the Middle Atlantic area in 1966 and 72,000 mt for the Chesapeake Bay area in 1969. By 1972 several plants in New Jersey and Delaware closed and only the plant at Port Monmouth remained. Between 1972 and 1981 landings shifted dramatically in favor of Chesapeake Bay plants, with annual landings for the area often exceeding the Middle Atlantic area landings fourfold (1975, 1977-80). Between 1972 and 1981, annual landings from both areas combined averaged 68% of the total landings for the entire Atlantic menhaden fishery. During 1982-84 landings from the combined North Atlantic and Chesapeake Bay areas averaged 75% of the total landings for the entire fishery (Table 3).

Estimated numbers of fish caught in the Middle Atlantic area increased through the early 1970s and reached almost 400 million in 1976, although never approaching the record levels of over 1,000 million caught prior to 1961 (Table 9). Estimated numbers declined to 52.1 million by 1978 and remained below the 100 million level through 1982. After the closure of the plant at Port Monmouth, vessels from Chesapeake Bay began more frequent exploitation of waters in the Middle Atlantic and North Atlantic areas. By 1983 plants in Virginia processed an estimated 300.2 million fish harvested in Middle Atlantic waters. During the 1970s and early 1980s, age-2 fish predominated in catches from the Middle Atlantic area, with relatively large numbers of age-1 fish taken in 1972, 1976, and 1978 and age-3 fish in 1972, 1977, and 1984.

As processing facilities in New Jersey and Delaware closed in the 1960s, the number of active vessels fell sharply (Table 5). Before 1964 over 40 vessels landed Atlantic menhaden in the Middle Atlantic area, but by 1973 only 6 vessels were active, all based at the Port Monmouth plant. Between 1972 and 1981 nominal effort at the Port Monmouth plant averaged 114 vessel weeks, or 12% of the average annual effort expended in the Middle Atlantic area between 1955 and 1962 (Table 6).

Estimated total numbers of fish caught in the Chesapeake Bay area declined through the 1960s to a low of 254 million in 1969 (Table 10). Estimated numbers fluctuated thereafter, but generally tended to increase toward and beyond the 1,000 million level. In 1980 an estimated 2,015.8 million fish were harvested in the Chesapeake Bay area, the greatest number since 1959. The catch of 1982 also surpassed 2,000 million fish. As Chesapeake Bay area landings increased during the 1970s, age composition of the catch shifted towards a greater percentage of age-2 fish. Between 1955 and 1971 estimated numbers of age-1 fish outnumbered age-2 fish in 9 out of 17 years (Table 10). Between 1972 and 1984 estimated numbers of age-2 fish predominated over age-1 fish in 10 of 13 years; in 1983 age-2 fish comprised 83% of the total estimated

Table 8

Estimated numbers (10^6) of Atlantic menhaden by age caught by purse seine vessels in the North Atlantic area, 1955-84.

	Age (yr)									
Year	0	1	2	3	4	5	6	7	8-10	Total
1955	—	—	0.42	23.74	114.62	21.94	7.94	0.93	0.38	167.97
1956	—	—	11.79	69.51	15.89	81.25	12.91	2.50	0.72	194.57
1957	—	2.01	83.87	35.03	29.42	16.15	17.13	2.83	0.46	186.90
1958	—	0.13	44.18	20.59	7.08	5.76	4.36	2.00	0.09	84.19
1959	—	8.37	37.13	95.97	10.59	4.06	4.27	2.08	0.90	163.37
1960	—	—	88.64	34.87	40.53	6.52	2.39	0.60	0.11	173.66
1961	—	—	5.11	107.15	6.76	12.27	1.35	0.49	0.14	133.27
1962	—	—	3.04	29.25	77.72	9.88	8.94	1.25	0.62	130.70
1963	—	—	1.34	10.58	14.48	23.54	5.94	1.64	0.30	57.82
1964*	—	—	1.92	5.86	4.12	5.17	4.59	0.99	0.17	22.82
1965	—	—	0.82	4.13	2.35	1.49	1.11	0.57	0.06	10.54
1966	—	—	0.11	1.33	1.15	0.16	0.11	0.11	0.04	3.00
1967	—	—	0.78	1.85	0.66	0.04	—	—	—	3.33
1968	—	—	1.65	5.63	2.16	0.27	0.02	—	—	9.73
1969**	—	—	0.49	4.64	2.95	0.13	—	—	—	8.20
1970	—	—	15.00	1.04	—	—	—	—	—	16.04
1971	—	—	4.97	32.31	11.62	1.44	—	—	—	50.34
1972	—	—	2.76	29.78	5.17	0.86	—	—	—	38.57
1973	—	—	108.26	11.62	0.77	0.34	—	—	—	120.99
1974	—	—	88.29	42.07	2.45	1.35	—	—	—	134.15
1975	—	—	79.66	33.12	4.64	0.20	0.10	—	—	117.72
1976	—	0.09	127.16	26.38	6.20	0.28	—	—	—	160.11
1977	—	—	6.09	33.42	10.58	1.37	0.07	—	—	51.53
1978	—	—	32.80	87.81	22.74	2.92	—	—	—	146.26
1979	—	1.38	98.05	56.29	16.77	1.47	0.09	—	—	174.06
1980	—	—	7.23	94.10	52.52	11.50	0.92	—	—	166.27
1981	—	—	29.90	62.14	44.44	15.00	1.27	—	—	152.76
1982	—	—	28.94	84.42	12.51	4.89	0.46	0.32	—	131.55
1983	—	—	123.28	46.94	17.83	2.19	0.23	—	—	190.46
1984	—	—	8.74	83.17	18.76	5.48	0.14	—	—	116.29

*1955-64 data from Nicholson (1975).

**1965-69 data from database used by Ahrenholz et al. (1987).

number of fish caught in the Chesapeake Bay area. Relatively large numbers of age-0 fish were taken in the Chesapeake Bay area during 1981, 1983, and 1984, and also large numbers of age-3 fish were caught 1978-84 compared with 1973-77.

The number of vessels fishing from plants in Chesapeake Bay remained fairly stable during 1972-84, ranging from 19 to 26 (Table 5). During the same period nominal effort declined from the record high levels of the mid-1960s (838 vessel weeks in 1965) and stabilized near the 600 vessel-week level (Table 6).

Combined CPUE values for the Middle Atlantic and Chesapeake Bay areas[6] declined through the mid-1970s to 211 mt/vessel week in 1975 (Table 7). From 1976 through 1981 CPUE values remained above the 300 mt/vessel week level. In 1983 combined CPUE for the North Atlantic and Chesapeake Bay areas peaked at 454 mt/vessel week.

South Atlantic

Landings in the South Atlantic area remained fairly stable during the 1960s, despite the large fluctuations in other fishing areas. Landings gradually increased through the late 1970s (Table 3). By 1981 South Atlantic landings totaled 79,100 mt, a record for this area for the period 1955-84. The plant at Southport, NC, annually accounted for a majority of the landings in the South Atlantic area, and closure of this plant after the 1983 fishing season is reflected in the 1984 landings for the area of only 19,000 mt.

Historically, catches from the South Atlantic area have consisted primarily of age-1 and -2 menhaden. For the period 1972-84 these age classes annually comprised between 62% and almost 100% of the total catch from the area (Table 11). In 1981, 1983, and 1984, significant numbers of age-0 fish were caught. In 1981 over 42 million age-0 fish were captured, primarily during October in North Carolina estuarine waters. During 1983 and 1984 most of the age-0 fish harvested in the South Atlantic area were caught by vessels from Virginia off the North Carolina coast but were processed in Reedville. Similarly, in 1982-84 some older fish (ages 4

Table 9

Estimated numbers (10^6) of Atlantic menhaden by age caught by purse seine vessels in the Middle Atlantic area, 1955-84.

	Age (yr)									
Year	0	1	2	3	4	5	6	7	8-10	Total
1955	—	16.31	510.22	211.26	159.33	12.96	2.20	0.91	0.16	913.35
1956	—	190.59	786.15	211.23	19.53	22.93	8.31	3.19	1.27	1,243.20
1957	—	410.30	846.46	42.46	20.44	9.55	8.73	0.48	0.56	1,338.98
1958	—	22.61	795.94	18.33	1.81	1.19	0.69	0.40	0.34	841.31
1959	—	875.53	448.11	168.08	4.38	2.06	2.00	1.69	0.33	1,502.18
1960	—	12.27	1,140.56	16.23	26.50	6.35	1.53	0.44	0.12	1,204.00
1961	—	3.47	164.16	741.82	6.04	6.95	0.89	0.32	0.10	923.75
1962	—	11.77	193.37	145.80	288.26	16.45	13.84	1.23	0.08	670.80
1963	—	157.90	232.62	39.94	21.56	19.41	2.95	1.24	0.15	475.77
1964*	—	3.74	37.91	32.64	10.15	2.04	1.86	0.23	0.15	88.72
1965	—	22.88	52.23	49.28	7.89	0.32	0.03	0.18	—	132.79
1966	—	3.30	10.35	3.45	1.10	0.03	—	—	—	18.24
1967	—	9.09	11.24	16.37	1.65	0.25	0.01	—	—	38.63
1968	—	0.61	31.44	20.07	5.55	0.30	0.04	—	—	58.00
1969**	—	0.03	6.13	11.02	0.97	0.02	0.01	—	—	18.18
1970	—	12.28	50.09	3.27	0.61	—	—	—	—	66.25
1971	—	12.07	22.60	9.16	1.54	0.16	—	—	—	45.53
1972	—	29.38	46.88	48.65	9.61	0.52	—	—	—	135.03
1973	—	5.66	117.36	24.80	5.96	—	—	—	—	153.78
1974	—	10.80	231.64	2.46	—	—	–	—	—	244.90
1975	—	—	97.30	5.70	1.01	—	—	—	—	104.01
1976	—	51.22	330.92	13.25	1.07	—	—	—	—	396.46
1977	—	4.90	120.18	39.18	7.00	0.03	0.04	—	—	171.33
1978	—	26.36	24.64	1.10	—	—	--	—	—	52.10
1979	—	0.29	48.11	27.49	2.52	—	—	—	—	78.42
1980	—	0.50	47.25	11.95	3.15	0.32	0.05	—	—	63.23
1981	—	0.30	48.90	16.77	1.90	0.37	—	—	—	68.23
1982	—	8.40	49.28	9.63	—	—	—	—	—	67.31
1983	—	5.85	281.97	11.92	0.24	0.24	—	—	—	300.22
1984	—	6.59	86.22	57.12	8.20	2.56	—	—	—	160.70

*1955-64 data from Nicholson (1975).

**1965-69 data from database used by Ahrenholz et al. (1987).

to 8) were also taken by Virginia vessels in the South Atlantic area after commencement of the North Carolina fall fishery, but they too were processed in Reedville. In both instances the fish in question were assigned to catches for the South Atlantic area. That they were taken in November and December demonstrates the recent tendency of vessels based in Virginia to fish as far south as Cape Hatteras and as late as December.

The number of vessels engaged in the fishery in the South Atlantic area remained fairly constant through the 1970s, reaching a high of 14 vessels in 1975 (Table 5). After 1981 the number of active vessels declined to 6 in 1984, primarily due to closure of the facility at Southport. Similarly, nominal effort was fairly stable in the South Atlantic area during the 1970s, averaging 243 vessel weeks annually between 1972 and 1979 (Table 6). By 1980 nominal effort declined, and in 1984 only 96 vessel weeks of effort were expended. CPUE in the area increased gradually through the 1970s and peaked at 331 mt/vessel week in 1981 (Table 7), a record for the South Atlantic. By 1984 CPUE declined to 198 mt/vessel week.

North Carolina fall fishery

During the 1960s annual landings of Atlantic menhaden in the North Carolina fall fishery averaged about 53,000 mt per year (Table 3). Between 1970 and 1976 annual landings declined below 20,000 mt per year, and in 1973 only 2,400 mt were landed. By 1977 landings improved, and through 1984 landings approximated pre-1970 levels. Landings of 68,700 mt in 1984 were the largest since 1966.

Catches from the North Carolina fall fishery during the 1970s were characterized by a paucity of age-3 and older fish (spawners) and by increasing harvests of age-0 fish (Table 12). The year classes of 1977, 1979, and 1981 were probably the strongest since the late 1960s (Ahrenholz et al. 1987), and they contributed significantly as age-3+ fish in the North Carolina fall fishery in 1981-84.

Starting in 1974, vessels in the North Carolina fall fishery began harvesting large numbers of age-0 fish (Table 12), and in 1979 a record estimated number of 1,478.0 million age-0 Atlantic menhaden were caught. This represented 91% of the total estimated number of fish caught in the North Carolina fall fishery that year.

Table 10

Estimated numbers (10^6) of Atlantic menhaden by age caught by purse seine vessels in the Chesapeake Bay area, 1955-84.

	Age (yr)									
Year	0	1	2	3	4	5	6	7	8-10	Total
1955	12.18	334.24	382.92	11.52	5.17	0.43	—	—	—	746.46
1956	—	674.37	66.90	0.49	—	—	—	—	-	741.76
1957	1.92	1,057.35	176.58	3.22	0.22	0.08	—	—	—	1,239.37
1958	0.48	490.88	561.76	5.25	0.90	0.39	-	—	-	1,059.66
1959	10.71	2,124.56	281.10	19.57	—	—	—	—	—	2,435.94
1960	—	142.58	666.94	2.64	—	—	—	—	—	812.16
1961	—	327.80	214.20	204.34	0.32	0.16	—	—	—	746.82
1962	42.40	204.08	370.64	32.78	35.29	0.27	—	—	—	685.46
1963	51.54	318.64	192.83	45.43	0.75	—	—	—	—	609.19
1964*	227.28	170.58	314.05	27.90	0.64	—	—	—	—	740.45
1965	68.18	485.23	104.50	13.52	0.32	—	0.08	—	—	671.82
1966	214.14	220.72	210.35	10.65	0.65	0.17	—	—	—	656.69
1967	6.62	211.81	143.74	18.42	0.27	—	—	—	—	380.86
1968	41.44	148.41	232.33	25.81	0.38	0.09	—	—	—	448.47
1969**	46.39	65.40	125.32	15.87	0.97	—	—	—	—	253.95
1970	2.74	500.14	226.02	21.51	1.07	0.07	—	—	—	751.56
1971	40.03	90.16	290.58	45.53	4.27	0.87	—	—	—	471.44
1972	0.17	598.71	274.29	92.67	4.34	0.48	—	—	—	970.65
1973	18.77	426.02	714.71	2.12	0.28	—	—	—	—	1,161.90
1974	16.67	426.06	406.11	2.95	—	—	—	—	—	851.79
1975	44.01	321.69	549.49	5.66	0.20	—	—	—	—	921.05
1976	14.43	881.59	678.06	2.40	0.52	—	—	—	—	1,577.00
1977	4.30	518.85	1,422.31	4.56	0.09	—	—	—	—	1,950.11
1978	0.12	337.24	1,080.06	36.71	—	—	—	—	—	1,454.12
1979	5.15	453.20	921.80	22.38	—	—	—	—	—	1,402.52
1980	7.79	838.39	1,092.17	74.20	3.33	—	—	—	—	2,015.88
1981	70.95	261.76	1,027.91	30.95	1.01	—	—	—	—	1,392.58
1982	8.08	518.87	1,318.73	166.61	—	—	—	—	—	2,012.28
1983	167.24	140.35	1,511.17	10.85	0.43	—	—	—	—	1,830.04
1984	186.94	450.87	693.16	88.07	—	—	—	—	—	1,419.04

*1955-64 data from Nicholson (1975).

**1965-69 data from database used by Ahrenholz et al. (1987).

Over 1,000 million age-0 fish were taken again in 1981 and numbers harvested in 1984 approximated this level.

During the late 1960s poor prospects of fish abundance in the North Carolina fall fishery contributed to a decline in the number of active vessels in the fishery (Nicholson 1975). The number of vessels dropped sharply to only 5 in 1972 and 4 in 1973 (Table 5). As catches improved during the late 1970s, the number of vessels increased to as many as 19 in 1980 and 1981, but then fell to 12 by 1984. Nominal effort increased from 1972 to 1984, approaching the 150-vessel-week level twice (1979 and 1983) (Table 6), and generally fluctuated about the 100-vessel-week level during the remainder of the period. CPUE increased throughout the late 1970s and early 1980s and exceeded levels observed during the early 1960s (Table 7); in 1984 a record high for the North Carolina fall fishery of 545 mt/vessel week was recorded.

Length and Weight Statistics

Simple mean lengths and weights for Atlantic menhaden sampled from 1972 to 1984 are presented by area caught, quarter, and age (Appendix Tables 2-13). Nicholson (1975) reported that the mean length of age 0-4 fish sampled at various ports increased through the mid- to late 1960s. He concluded that these changes were significant and indicated increased growth rates over the period. During the 1970s and early 1980s a reversal of this trend was observed. In all areas for 1972-84, the mean length of age 1-4 fish tended to decline. This trend is most apparent when coastwide annual mean lengths and weights at age are summarized (Appendix Tables 7 and 13); the mean length of age 1-4 Atlantic menhaden declined about 30-60 mm over the period. Because fish weight varies as a power of length, the decline in mean weight over the same period is even more striking and holds important ramifications regarding stock biomass and yield from the fishery (Vaughan and Smith 1986a). The mean weights of Atlantic menhaden age 1-4 in 1972 were 128, 330, 547, and 631 g, respectively, but in 1984 mean weights for respective age groups were 78, 149, 288, and 405 g (Appendix Table 13).

Table 11

Estimated numbers (10^6) of Atlantic menhaden by age caught by purse seine vessels in the South Atlantic area, 1955-84.

	Age (yr)									
Year	0	1	2	3	4	5	6	7	8-10	Total
1955	6.51	292.84	113.04	13.47	11.38	—	—	—	—	437.24
1956	—	1,147.88	10.91	0.89	—	—	—	—	—	1,159.68
1957	13.27	117.91	231.56	0.42	—	—	—	—	—	363.16
1958	1.47	315.20	135.39	8.25	0.26	—	—	—	—	460.57
1959	—	1,203.39	48.96	0.84	—	—	—	—	—	1,073.19
1960	13.86	111.84	273.73	—	—	—	—	—	—	399.43
1961	—	490.44	74.96	54.36	0.30	—	—	—	—	620.06
1962	2.21	297.55	250.30	1.81	—	—	—	—	—	551.87
1963	—	178.22	220.55	0.33	—	—	—	—	—	399.10
1964*	1.66	510.22	184.55	—	—	—	—	—	—	696.43
1965	3.77	200.64	194.08	0.33	0.05	—	—	—	—	398.86
1966	—	254.80	67.29	0.50	—	—	—	—	—	322.59
1967	0.33	329.15	63.81	0.03	—	—	—	—	—	393.31
1968	0.37	212.34	204.96	0.52	—	—	—	—	—	418.19
1969**	0.05	258.12	113.58	0.32	—	—	—	—	—	372.06
1970	—	336.96	164.48	—	—	—	—	—		501.44
1971	1.28	145.83	195.62	0.03	—	—	—	—	—	342.75
1972	—	334.44	160.86	0.17	—	—	—	—	—	495.47
1973	—	148.18	212.50	0.07	—	—	—	—	—	360.69
1974	—	151.28	243.65	0.82	—	—	—	—	—	395.74
1975	—	311.62	335.17	4.15	0.79	—	—	—	—	651.72
1976	7.85	598.79	185.82	—	—	—	—	—	—	792.47
1977	—	337.97	484.29	1.89	—	—	—	—	—	824.14
1978	—	162.61	489.21	96.82	0.42	—	—	—	—	749.06
1979	9.25	87.19	477.36	13.09	—	—	—	—	—	586.90
1980	0.36	376.81	279.07	26.04	0.29	—	—	—	—	682.57
1981	42.03	190.57	547.89	99.07	0.12	—	—	—	—	879.69
1982	4.33	258.85	286.95	104.18	0.76	—	0.07	—	—	655.15
1983	96.74	165.09	274.43	19.87	11.43	1.74	—	—	0.46	569.76
1984	137.69	156.02	83.83	10.05	—	—	—	—	—	387.59

*1955-64 data from Nicholson (1975).

**1965-69 data from database used by Ahrenholz et al. (1987).

An explanation for this phenomenon may be threefold (ASMFC 1981; Ahrenholz et al. 1987), but it is unknown whether these interpretations are independent of, or confound, one another. First, Atlantic menhaden are protracted spawners and prevailing environmental factors may favor success of the later (late winter or spring) spawn, rather than the earlier (fall or winter) spawn. Thus, the later-spawned young-of-the-year would have a shorter first growing season and presumably would enter the fishery as age-1 and -2 fish at a smaller size than would fall or early winter spawned fish. Second, since 1970 the center of fishing activity has shifted southward from the North Atlantic and the Middle Atlantic areas to the Chesapeake Bay and the South Atlantic areas. Since Atlantic menhaden stratify along the East Coast of the U.S. by size and age during summer, with larger individuals of a given age class occurring in more northern latitudes (Nicholson 1971b), the fishery has concentrated fishing in locations of smaller individuals of a given age class. Third, Atlantic menhaden exhibit density-dependent growth. The relatively strong year classes of 1975, 1979, 1981, and 1983 produced smaller-than-average-sized fish at a given age. Figures 2 and 3 show this size differential of sampled fish at age for the 1967 and 1983 fishing seasons. These length frequency distributions portray not only size differences at age between years, but also geographical size differences at age within years.

Summary

The purse seine fishery for Atlantic menhaden declined through the 1960s when fish became scarce in the northern half of their range due to poor recruitment and truncation of the stock's age structure. During the mid- to late 1970s recruitment improved and the age structure broadened. As fish again became available in New England waters, up to four reduction plants processed Atlantic menhaden in the North Atlantic fishing area during the mid-1970s. However, by the late 1970s and early 1980s local factory-odor abatement problems forced several of these plants to close. In the Middle Atlantic area only one plant processed fish through the 1970s, but it closed after 1981. In the Chesapeake Bay area the number of active plants and the size of the fleet remained fairly stable through the early 1980s. Beginning in 1983 the Chesapeake Bay fleet increased its efforts in the Middle Atlantic and North Atlantic areas and also along the North Carolina coast

Table 12

Estimated numbers (10^6) of Atlantic menhaden by age caught by purse seine vessels during the North Carolina fall fishery, 1955-84.

	Age (yr)									
Year	0	1	2	3	4	5	6	7	8-10	Total
1955	742.32	30.76	51.08	7.32	16.71	2.74	0.39	—	0.10	851.42
1956	36.37	60.42	26.97	37.48	9.36	46.50	7.48	1.03	—	225.61
1957	284.39	12.41	23.30	15.60	20.72	14.74	11.07	0.95	0.08	383.26
1958	104.11	29.34	98.08	19.63	7.20	8.60	4.04	2.48	—	273.48
1959	0.69	6.87	35.99	103.81	18.44	5.75	6.09	0.78	0.54	178.96
1960	58.31	14.32	38.76	22.63	35.17	10.90	4.03	1.32	0.42	185.86
1961	0.25	10.71	45.17	101.90	5.76	10.00	0.62	—	—	174.41
1962	6.97	0.71	17.17	7.61	22.10	4.15	1.82	0.50	—	61.03
1963	45.35	69.47	61.86	26.25	8.18	9.43	1.53	0.45	0.11	222.63
1964*	73.65	19.41	66.55	17.10	3.03	0.64	0.17	0.09	—	180.64
1965	177.16	36.46	69.77	10.50	1.57	—	—	—	—	295.46
1966	135.31	72.00	116.03	15.76	0.98	—	—	—	—	340.09
1967	—	83.16	46.09	36.09	2.51	0.20	—	—	—	168.05
1968	112.45	16.00	68.58	13.66	2.59	0.32	—	—	—	213.59
1969**	111.69	48.78	38.80	15.96	0.55	—	—	—	—	215.79
1970	18.68	21.47	18.34	6.81	2.34	0.04	—	—	—	67.67
1971	31.55	15.22	10.55	1.26	0.41	0.04	—	—	—	59.03
1972	50.00	18.75	3.68	1.80	—	—	—	—	—	74.22
1973	37.21	8.68	0.10	0.02	—	—	—	—	—	46.01
1974	298.88	48.55	16.28	0.29	0.05	—	—	—	—	364.03
1975	254.63	86.66	24.91	1.60	—	—	—	—	—	367.80
1976	251.94	80.27	19.13	5.94	0.16	—	—	—	—	357.44
1977	480.33	142.83	48.90	4.41	0.13	—	—	—	—	676.59
1978	457.30	164.24	42.49	12.14	6.93	0.55	—	—	—	683.66
1979	1,478.07	81.07	57.96	8.67	2.47	—	—	—	—	1,628.23
1980	80.14	262.36	32.51	16.42	9.94	2.54	0.47	—	—	404.37
1981	1,074.60	246.04	156.87	13.26	—	—	—	—	—	1,490.76
1982	101.70	133.32	55.65	14.82	3.05	0.89	—	—	—	309.44
1983	700.44	205.93	102.21	24.78	17.43	0.84	—	—	—	1,051.63
1984	969.59	410.69	20.13	33.10	23.37	7.17	0.37	—	—	1,464.41

*1955-64 data from Nicholson (1975).

**1965-69 data from database used by Ahrenholz et al. (1987).

during late fall and early winter. In the South Atlantic area, the number of active plants remained relatively unchanged through the early 1980s, although a major facility closed after 1983; consequently, fleet size and landings also declined. Participation in the North Carolina fall fishery increased through the 1970s and early 1980s as the prospects for greater catches improved.

As the Atlantic menhaden stock has rebuilt, landings increased from 161,600 mt in 1969 to 418,600 mt in 1983; coastwide estimates of numbers of fish landed increased from 969.1 million in 1971 to almost 4,000 million in 1981. Through the 1970s and early 1980s greater numbers of age-0 menhaden were harvested during the North Carolina fall fishery. In turn, age-0 fish made increasingly greater contributions to annual coastwide estimates of numbers of Atlantic menhaden landed. Also as the stock has rebuilt, the mean length of sampled fish ages 1-4 declined 30-60 mm, while the mean weight of the same age classes declined 50-250 g.

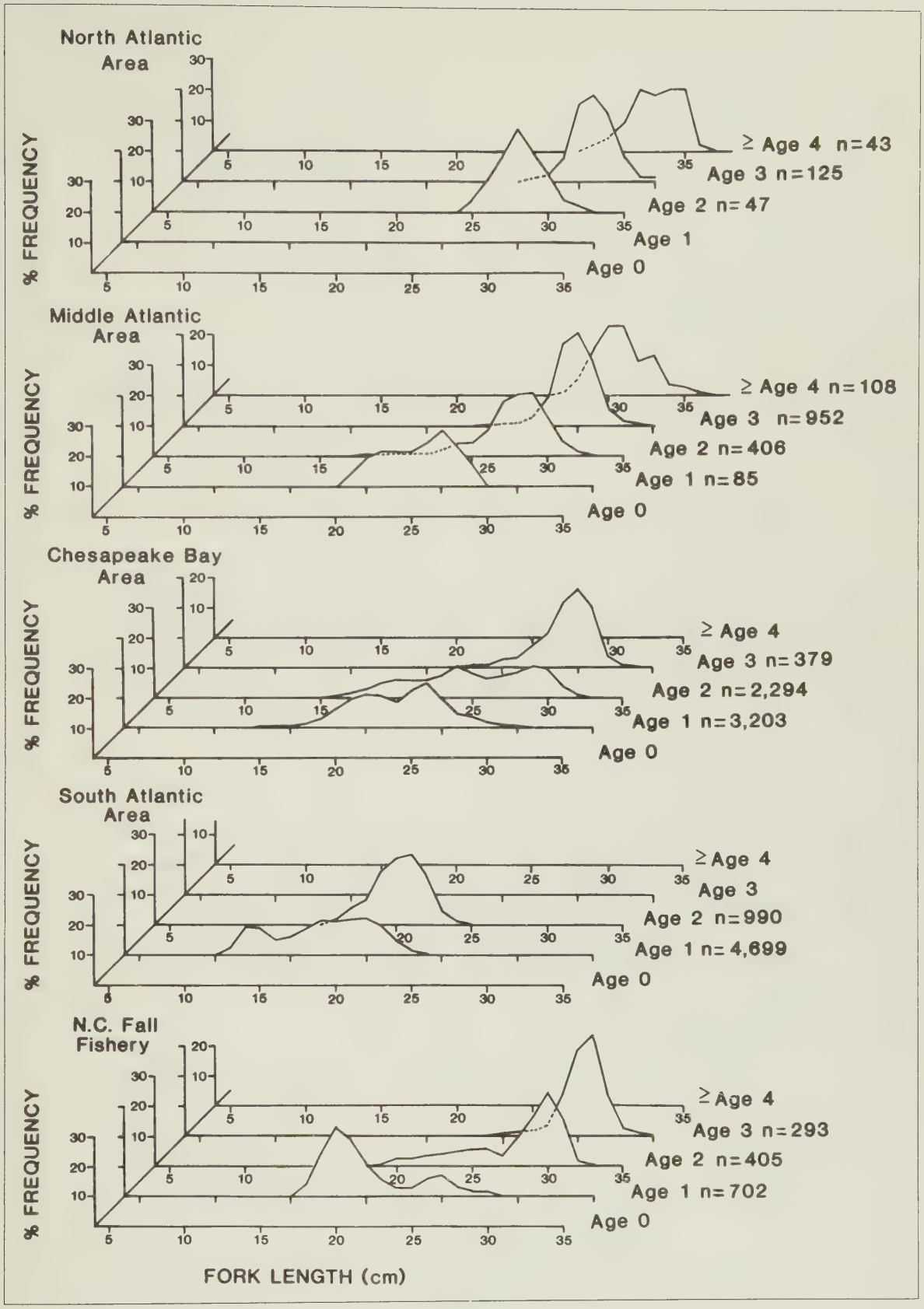

Figure 2

Length frequency distributions of Atlantic menhaden sampled from the purse seine fishery during 1967.

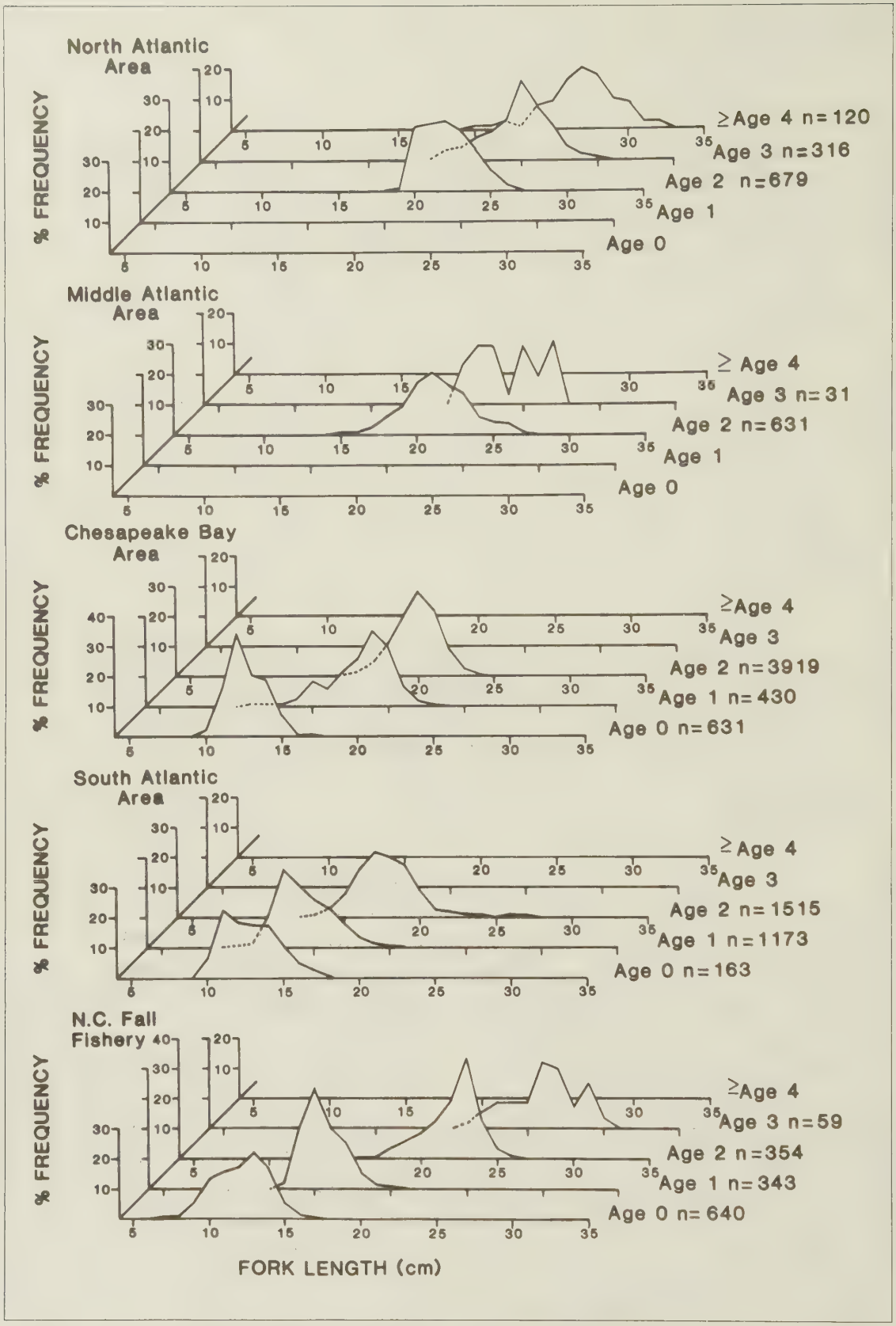

Figure 3

Length frequency distributions of Atlantic menhaden sampled from the purse seine fishery during 1983.

Acknowledgments

We wish to express our appreciation to menhaden plant owners and managers who provided records of vessel offloadings and also access for our port agents to sample Atlantic menhaden landings. We thank all past and present members of the Menhaden Program at the Beaufort Laboratory who contributed to the Atlantic menhaden database. We are especially indebted to Charles W. Krouse, Jr., for his computer programming talents, Dean W. Ahrenholz for his helpful suggestions and encouragement during preparation of the manuscript, and Beverly W. Harvey who showed exceptional patience and skill in preparing our multitudinous tables. Sheryan P. Epperly, John V. Merriner, James R. Waters, and an anonymous reviewer for the Technical Report series made valuable comments on various drafts of the manuscript.

The authors wish to dedicate this report to the memory of Robert B. Chapoton, who served as a Branch Leader in the Menhaden Program at the Beaufort Laboratory until his untimely death in May 1985. Bob's career with the National Marine Fisheries Service (formerly the Bureau of Commercial Fisheries) spanned almost three decades. During the latter half of his tenure Bob maintained Atlantic and gulf menhaden catch and effort data, annually formulated quantitative forecasts of menhaden landings, and served as scientific liaison to the menhaden industry and the Atlantic and Gulf States Marine Fisheries Commissions. During the late 1970s and early 1980s, most of Bob's boundless energies were directed toward developing state management options for Atlantic menhaden. Bob's contacts in the menhaden industry and fisheries management circles were also counted among his friends. His wit, steadfastness, and friendship will be missed by all who knew him.

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Appendix Table 1

Quarterly time increments used in subsequent appendices for Atlantic menhaden.

Quarter	Ending date of first week	Ending date of last week
1	>2/29	<6/01
2	>5/30	<8/30
3	>8/29	<11/29
4	>11/28	<2/29*

*February of next calendar year, but same fishing season.

Appendix Table 2

Mean fork length (mm) of Atlantic menhaden sampled from the North Atlantic area by quarter and age, 1972-84.

	Quarter 1 Age (yr)				Quarter 2 Age (yr)							Quarter 3 Age (yr)				
Year	2	3	4	5	1	2	3	4	5	6	7	2	3	4	5	6
1972	—	—	—	—	—	297	319	320	325	—	—	—	—	—	—	—
1973	—	—	—	—	—	252	303	338	—	—	—	275	311	326	332	—
1974	—	—	—	—	—	253	294	335	324	—	—	263	300	314	338	—
1975	244	—	—	—	—	246	282	301	326	333	—	262	282	313	—	—
1976	220	—	—	—	198	240	278	297	310	—	—	252	288	301	—	—
1977	—	—	—	—	—	246	265	277	287	290	—	267	280	294	298	330
1978	211	221	240	—	—	217	240	286	295	—	—	238	258	292	302	—
1979	207	267	—	—	191	230	262	276	295	—	—	241	264	282	316	313
1980	228	240	240	—	—	239	260	274	284	294	—	267	284	290	294	304
1981	202	229	272	283	—	220	257	284	294	299	—	255	274	292	303	317
1982	202	230	271	314	—	217	238	270	297	302	317	233	243	283	—	—
1983	—	—	—	—	—	219	246	265	293	300	—	241	262	273	285	—
1984	—	—	—	—	—	236	251	271	282	291	—	252	268	283	288	—

Appendix Table 3

Mean fork length (mm) of Atlantic menhaden sampled from the Middle Atlantic area by quarter and age, 1972-84.

	Quarter 1 Age (yr)				Quarter 2 Age (yr)						Quarter 3 Age (yr)				
Year	1	2	3	4	1	2	3	4	5	6	1	2	3	4	5
1972	—	299	311	307	223	249	314	321	337	—	223	277	312	323	—
1973	—	—	—	—	—	238	304	341	—	—	233	254	295	331	—
1974	—	211	—	—	211	231	288	—	—	—	215	244	287	—	—
1975	—	224	—	—	—	229	281	307	—	—	—	249	279	296	—
1976	176	197	285	—	185	222	281	298	—	—	189	231	291	320	—
1977	—	237	259	281	185	224	250	273	267	322	172	234	263	285	—
1978	—	216	221	246	—	226	241	275	—	—	—	236	254	273	—
1979	—	—	—	—	202	231	251	265	—	—	214	243	263	281	—
1980	—	—	—	—	—	218	244	273	296	281	202	234	258	277	—
1981	—	188	210	229	—	221	226	260	270	—	199	235	246	273	309
1982	—	—	—	—	181	220	233	—	—	—	179	228	238	—	—
1983	—	181	—	—	173	207	225	—	—	—	185	234	254	278	288
1984	—	—	—	—	172	208	230	289	301	—	170	219	253	283	—

Appendix Table 4

Mean fork length (mm) of Atlantic menhaden sampled from the Chesapeake Bay area by quarter and age, 1972-84.

	Quarter 1 Age (yr)				Quarter 2 Age (yr)						Quarter 3 Age (yr)					Quarter 4 Age(yr)				
Year	1	2	3	4	0	1	2	3	4	5	0	1	2	3	4	0	1	2	3	4
1972	—	—	—	—	—	197	267	305	316	344	—	207	284	312	315	123	201	254	—	—
1973	—	—	—	—	—	178	222	279	323	—	131	212	233	291	—	124	217	250	—	—
1974	—	—	—	—	124	176	221	281	—	—	136	197	233	293	—	128	183	—	—	—
1975	—	—	—	—	—	154	204	257	294	—	126	176	211	278	—	116	168	207	—	—
1976	153	209	288	302	—	164	199	278	284	—	128	163	210	—	—	—	162	204	—	—
1977	160	205	277	—	—	158	183	241	—	—	127	163	193	231	—	—	190	210	275	300
1978	142	182	209	—	—	162	192	225	—	—	129	173	203	232	—	—	[illegible]	—	[illegible]	—
1979	167	194	229	—	—	174	198	223	—	—	133	170	205	237	[illegible]	—	[illegible]	—	[illegible]	—
1980	—	195	212	—	—	170	196	212	220	—	124	165	204	225	229	122	156	—	—	—
1981	—	177	198	—	128	176	189	206	249	—	129	176	202	226	237	—	—	[illegible]	—	[illegible]
1982	160	180	193	—	—	168	193	204	—	—	140	181	206	229	—	—	—	—	—	[illegible]
1983	161	181	198	—	—	174	194	206	200	—	126	186	209	211	—	118	—	[illegible]	—	[illegible]
1984	158	184	207	—	113	171	197	215	—	—	115	164	203	233	—	—	—	—	—	[illegible]

Appendix Table 5

Mean fork length (mm) of Atlantic menhaden sampled from the South Atlantic area by quarter and age, 1972-84.

	Quarter 1 Age (yr)				Quarter 2 Age (yr)						Quarter 3 Age (yr)						Quarter 4 Age (yr)								
Year	1	2	3	4	1	2	3	4	5	6	0	1	2	3	4	5	0	1	2	3	4	5	6	7	8
1972	169	198	—	—	160	201	286	—	—	—	—	174	204	—	—	—	—	—	—	—	[illegible]	—	[illegible]	—	—
1973	151	185	—	—	165	193	223	—	—	—	—	195	210	—	[illegible]	—	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]	—
1974	138	214	284	—	177	218	262	—	—	—	—	183	228	—	[illegible]	—	—	—	—	—	—	—	—	—	[illegible]
1975	159	197	241	—	161	191	236	311	—	—	—	175	204	—	[illegible]	—	[illegible]	—	[illegible]	—	—	—	—	—	—
1976	159	183	—	—	153	201	—	—	—	—	96	165	216	—	—	—	—	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]	—
1977	115	182	—	—	135	190	264	—	—	—	—	160	190	—	—	—	—	—	—	—	—	—	—	—	—
1978	126	170	200	280	137	184	203	214	—	—	—	145	197	203	[illegible]	—	[illegible]	—	[illegible]	—	—	—	—	—	—
1979	135	174	219	—	153	185	205	—	—	—	89	175	202	230	[illegible]	—	[illegible]	—	—	—	[illegible]	[illegible]	[illegible]	[illegible]	—
1980	122	176	—	—	135	183	200	—	—	—	115	147	205	224	251	—	—	—	—	—	—	—	—	—	—
1981	154	171	202	—	141	187	204	209	—	—	92	152	198	216	—	—	[illegible]	—	[illegible]	—	—	—	[illegible]	[illegible]	—
1982	135	171	191	—	143	179	193	210	—	275	93	148	191	203	—	—	—	—	—	—	—	—	—	—	—
1983	125	160	198	197	141	173	200	222	—	—	134	146	188	206	205	287	123	—	268	275	284	278	—	—	329
1984	130	169	—	—	155	185	205	—	—	—	103	165	194	209	—	—	115	142	[illegible]	—	—	—	—	—	—

Appendix Table 6

Mean fork length (mm) of Atlantic menhaden sampled during the North Carolina fall fishery by quarter and age, 1972-84.

	Quarter 3 Age (yr)					Quarter 4 Age (yr)						
Year	0	1	2	3	4	0	1	2	3	4	5	6
1972	—	182	264	313	—	118	168	262	314	—	—	—
1973	—	—	—	—	—	133	210	294	307	—	—	—
1974	—	176	—	—	—	120	158	263	287	291	—	—
1975	134	160	218	261	—	118	153	229	276	—	—	—
1976	113	173	216	–	—	105	159	253	291	318	—	—
1977	88	167	220	—	—	116	162	224	267	298	—	—
1978	108	146	—	—	—	121	171	221	275	297	302	—
1979	85	197	217	235	—	116	183	226	261	281	—	—
1980	116	159	214	223	240	114	147	212	283	291	298	297
1981	117	171	215	220	—	103	159	204	—	—	—	—
1982	—	152	213	225	—	112	162	222	254	276	296	—
1983	140	163	221	229	—	119	151	218	266	277	313	—
1984	113	152	213	246	—	110	144	225	272	279	286	299

Appendix Table 7

Mean fork length (mm) of Atlantic menhaden sampled coastwide by age, 1972-84.

	Age (yr)								
Year	0	1	2	3	4	5	6	7	8
1972	119	194	261	310	319	335	—	—	—
1973	131	202	220	302	334	332	—	—	—
1974	123	184	227	293	328	327	—	—	—
1975	122	163	215	278	304	326	333	—	—
1976	107	160	215	285	298	310	—	—	—
1977	116	151	199	260	280	287	314	—	—
1978	120	155	196	236	288	298	—	—	—
1979	111	167	205	256	278	298	313	—	—
1980	115	147	201	257	279	290	296	–	—
1981	112	159	196	237	284	295	304	—	—
1982	116	160	194	216	268	297	296	317	—
1983	124	154	198	243	269	294	300	—	329
1984	112	161	198	248	277	286	294	—	—

Appendix Table 8

Mean weight (g) of Atlantic menhaden sampled from the North Atlantic area by quarter and age, 1972-84.

	Quarter 1 Age (yr)				Quarter 2 Age (yr)							Quarter 3 Age (yr)				
Year	2	3	4	5	1	2	3	4	5	6	7	2	3	4	5	6
1972	—	—	—	—	—	520	638	620	664	—		—	-		–	—
1973	—	—	—	—	—	302	559	682	—	—	—	353	538	625	674	—
1974	—	—	—	—	—	301	460	641	558	—	—	307	454	519	674	—
1975	267	—	—	—	—	291	426	512	691	654	—	329	411	550	—	—
1976	228	—	—	—	203	270	418	512	569	—	—	316	483	539	—	—
1977	—	—	—	—	—	297	391	449	517	444	—	404	445	528	517	654
1978	188	211	341	—	–	194	277	465	498	—	—	252	331	483	533	—
1979	161	358	—	—	130	238	342	408	491	—	—	265	361	454	592	708
1980	241	287	290	—	—	287	375	437	475	562	—	344	439	470	487	571
1981	160	262	402	458	—	204	334	447	489	470	—	332	401	458	506	572
1982	176	253	373	559	—	182	257	396	483	503	549	226	263	437	—	—
1983	—	—	—	—	—	183	278	352	458	506	—	234	304	360	383	—
1984	—	—	—	—	—	243	300	382	423	475	—	263	315	396	418	—

Appendix Table 9

Mean weight (g) of Atlantic menhaden sampled from the Middle Atlantic area by quarter and age, 1972-84.

	Quarter 1 Age (yr)				Quarter 2 Age (yr)						Quarter 3 Age (yr)				
Year	1	2	3	4	1	2	3	4	5	6	1	2	3	4	5
1972	—	558	582	583	205	316	632	686	753	—	210	427	607	685	—
1973	—	—	—	—	—	264	557	742	—	—	246	318	500	678	—
1974	—	186	—	—	176	236	442	—	—	—	188	294	450	—	—
1975	—	219	—	—	—	237	423	535	—	—	—	302	417	480	—
1976	83	147	427	—	131	223	422	531	—	—	129	247	498	730	—
1977	—	291	366	465	121	222	320	407	395	694	103	248	342	437	—
1978	—	198	212	295	—	218	271	404	—	—	—	259	330	406	—
1979	—	—	—	—	150	229	303	365	—	—	193	287	358	397	—
1980	—	—	—	—	—	195	299	397	516	440	153	253	329	409	—
1981	—	127	168	208	—	214	231	360	372	—	140	255	295	379	537
1982	—	—	—	—	103	202	256	—	—	—	105	237	265	—	—
1983	—	98	—	—	89	160	223	—	—	—	125	237	293	387	444
1984	—	—	—	—	93	176	261	497	584	—	111	221	328	432	—

Appendix Table 10

Mean weight (g) of Atlantic menhaden sampled from the Chesapeake Bay area by quarter and age, 1972-84.

	Quarter 1 Age (yr)				Quarter 2 Age (yr)						Quarter 3 Age (yr)					Quarter 4 Age (yr)				
Year	1	2	3	4	0	1	2	3	4	5	0	1	2	3	4	0	1	2	3	4
1972	—	—	—	—	—	134	345	488	551	669	—	149	403	524	569	31	140	290	—	—
1973	—	—	—	—	–	100	189	375	480	—	40	178	235	542	—	35	182	275	—	—
1974	—	—	—	—	30	104	198	384	—	—	45	137	231	415	—	39	118	—	—	—
1975	—	—	—	—	—	67	153	308	465	—	35	93	160	377	—	25	78	146	—	—
1976	63	164	353	416	—	78	142	350	321	—	36	77	167	—	—	—	76	166	—	—
1977	68	150	345	—	—	69	105	238	—	—	36	76	133	237	—	—	132	172	405	629
1978	48	109	170	—	—	78	129	214	—	—	38	95	160	252	—	—	-		-	—
1979	89	143	215	—	—	95	148	232	—	—	40	88	167	284		—		—	—	
1980	—	127	174	—	—	84	134	172	198	—	34	83	158	221	233	31	68	—	—	—
1981	—	105	138	—	42	93	122	161	247	—	37	92	148	221	285	—		—		
1982	74	105	128	—	—	83	129	156	—	—	53	113	168	242	—	–	—	—	-	—
1983	69	101	130	—	—	91	126	155	149	—	35	116	161	172	—	26		—		
1984	65	106	158	—	23	94	145	193	—	—	27	90	162	254	—		—		—	

Appendix Table 11

Mean weight (g) of Atlantic menhaden sampled from the South Atlantic area by quarter and age, 1972-84.

	Quarter 1 Age (yr)				Quarter 2 Age (yr)						Quarter 3 Age (yr)						Quarter 4 Age (yr)								
Year	1	2	3	4	1	2	3	4	5	6	0	1	2	3	4	5	0	1	2	3	4	5	6	7	8
1972	77	125	—	—	70	134	328	—	—	—	—	94	158	—	—		—		—			—		—	—
1973	61	114	—	—	82	127	222	—	—	—	—	139	183	—	—	—	—	—	—	—	—	—	—	—	—
1974	36	166	326	—	98	170	282	—	—	—	—	117	211	—	—	—	—	—	—	—		—	—	—	—
1975	65	123	205	—	73	113	202	458	—	—	—	97	155	—	—	—	—	—	—	—	—	—	—	—	—
1976	65	99	—	—	56	139	—	—	—	—	14	73	169	—	—	—	—	—	—	—	—	—	—	—	—
1977	24	100	—	—	41	119	378	—	—	—	—	79	127				—	—	—	—	—				
1978	32	87	148	359	43	107	147	167	—	—	—	51	142	162	—	—	—	—	—	—	—	—	—	—	—
1979	44	96	180	—	65	111	151	—	—	—	11	95	149	216	—	—	—		—				—		
1980	30	96	—	—	40	112	145	—	—	—	25	53	165	224	301	—	—	—	—				—	—	—
1981	62	84	139	—	46	117	150	141	—	—	12	56	144	203	—	—	—	—	—		—			—	—
1982	44	91	122	—	55	105	136	168	—	293	13	60	134	164	—	—	—	—	—	—	—	—	—	—	—
1983	34	74	135	117	49	93	145	195	—	—	42	56	123	174	177	430	30	—	337	382	427	465	—	—	700
1984	39	85	—	—	68	112	150	—	—	—	16	80	141	183	—	—	22	46	—	—	—	—	—	—	—

Appendix Table 12

Mean weight (g) of Atlantic menhaden sampled during the North Carolina fall fishery by quarter and age, 1972-84.

	Quarter 3 Age (yr)					Quarter 4 Age (yr)						
Year	0	1	2	3	4	0	1	2	3	4	5	6
1972	—	115	349	537	—	27	78	342	545	—	—	—
1973	—	—	—	—	—	41	168	457	581	—	—	—
1974	—	92	—	—	—	28	62	324	437	476	—	—
1975	39	70	179	305	—	28	59	224	376	—	—	—
1976	25	87	176	—	—	18	66	310	485	698	—	—
1977	10	85	202	—	—	25	72	205	372	511	—	—
1978	21	52	—	—	—	29	85	193	385	505	550	—
1979	9	151	193	239	—	23	98	207	330	415	—	—
1980	27	74	192	214	267	24	55	190	427	467	499	488
1981	22	84	185	203	—	17	66	147	—	—	—	—
1982	—	68	194	222	—	23	74	217	344	420	498	—
1983	48	75	213	237	—	28	57	197	359	402	602	—
1984	24	70	192	287	—	21	51	216	387	424	461	514

Appendix Table 13

Mean weight (g) of Atlantic menhaden sampled coastwide by age, 1972-84.

	Age (yr)								
Year	0	1	2	3	4	5	6	7	8
1972	28	128	330	547	631	688	—	—	—
1973	40	156	196	535	688	674	—	—	—
1974	31	116	212	453	607	587	—	—	—
1975	30	77	187	405	515	691	654	—	—
1976	20	69	194	445	518	569	—	—	—
1977	25	62	149	365	459	513	597	—	—
1978	28	68	142	260	467	513	—	—	—
1979	21	84	167	326	420	504	708	—	—
1980	25	57	152	351	441	484	542	—	—
1981	23	69	140	265	443	490	498	—	—
1982	28	79	138	200	388	487	461	549	—
1983	33	66	141	272	369	473	506	—	700
1984	24	78	149	288	405	450	488	—	—

Appendix Table 14

Coastwide estimated numbers of Atlantic menhaden (10^3) caught by purse seine vessels by age, quarter, and year, 1965-84 (quarters were summed before rounding to thousands).

	Age (yr)								
Quarter	0	1	2	3	4	5	6	7	8-10
1965									
1	—	24,594	36,482	4,981	1,527	59	1	<1	—
2	2,044	472,773	249,551	49,657	6,896	1,238	897	470	26
3	85,009	223,273	88,296	17,099	3,167	514	318	276	39
4	162,066	24,566	47,068	6,018	579			—	-
Totals	249,119	745,206	421,397	77,755	12,168	1,811	1,215	746	65
1966									
1	—	21,387	9,688	352	123	—	—	—	
2	13,171	324,656	173,120	9,844	1,999	287	54	53	17
3	203,273	177,016	176,851	15,817	1,768	73	55	55	18
4	133,008	27,760	44,477	5,686	—	—	—	—	
Totals	349,453	550,820	404,136	31,699	3,890	360	108	108	36
1967									
1	—	106,046	9,867	—	—	—	—	—	
2	—	305,108	151,252	20,997	1,953	252	12	—	—
3	6,949	154,262	77,825	29,403	1,020	36	—	—	—
4	—	67,788	26,722	22,375	2,117	201	—	—	—
Totals	6,949	633,203	265,667	72,775	5,090	489	12	—	—
1968									
1	—	67,978	73,278	445	—	—	—	—	—
2	216	209,463	290,789	32,421	5,096	263	45	—	—
3	41,591	90,757	144,930	24,796	4,318	538	14	—	—
4	112,451	9,166	29,954	8,024	1,261	182	—	—	—
Totals	154,258	377,364	538,951	65,686	10,675	983	58	—	—
1969									
1	—	41,580	15,601	—	—	—	—	—	—
2	2,265	218,702	165,668	18,064	3,609	150	9	—	—
3	56,334	82,440	72,814	16,993	1,279	—	—	—	
4	99,528	29,607	30,225	12,753	554	—	—		—
Totals	158,127	372,328	284,309	47,810	5,442	150	9	—	—
1970									
1	—	70,218	56,798	909	—	—	—	—	
2	—	562,968	286,132	18,646	614	—	—	—	-
3	6,823	228,440	120,291	9,458	1,991	73	—	—	—
4	14,595	9,225	10,704	3,621	1,414	39	—	—	—
Totals	21,418	870,851	473,924	32,634	4,019	112	—	—	—
1971									
1	—	7,003	36,787	265	12	—	—	—	—
2	—	137,410	324,056	56,594	10,050	947	—	—	—
3	41,781	113,963	153,849	30,050	7,370	1,524	—	—	—
4	31,073	4,912	9,623	1,377	412	41	—	—	—
Totals	72,854	263,288	524,315	88,286	17,844	2,512	—	—	—
1972									
1	—	30,736	21,186	662	83	—	—	—	-
2	—	444,020	336,688	128,158	13,497	1,675	—	—	—
3	—	454,230	127,993	43,010	5,541	186	—	—	—
4	50,162	52,283	2,602	1,235	—	—	—	—	—
Totals	50,162	981,269	488,469	173,065	19,121	1,861	—	—	—

Appendix Table 14 (Cont'd)

Coastwide estimated numbers of Atlantic menhaden (10^3) caught by purse seine vessels by age, quarter, and year, 1965-84 (quarters were summed before rounding to thousands).

	Age (yr)								
Quarter	0	1	2	3	4	5	6	7	8-10
1973									
1	—	20,392	34,267	1	—	—	—	—	—
2	—	129,110	932,303	30,159	5,466	—	—	—	—
3	11,783	370,298	182,392	8,453	1,538	343	—	—	—
4	44,196	68,671	3,974	17	—	—	—	—	—
Totals	55,979	588,471	1,152,936	38,630	7,004	343	—	—	—
1974									
1	—	54,309	49,149	369	—	—	—	—	—
2	5,263	265,781	815,300	40,695	1,611	1,196	—	—	—
3	14,874	235,642	105,800	7,234	838	149	—	—	—
4	295,415	80,946	15,720	288	46	—	—	—	—
Totals	315,552	636,678	985,969	48,586	2,495	1,345	—	—	—
1975									
1	—	28,999	102,153	1,712	—	—	—	—	—
2	—	346,071	761,003	35,817	5,508	200	101	—	—
3	69,478	243,243	197,866	11,594	1,120	—	—	—	—
4	229,162	101,650	25,505	1,122	—	—	—	—	—
Totals	298,640	719,963	1,086,527	50,245	6,628	200	101	—	—
1976									
1	—	108,892	104,100	55	—	—	—	—	—
2	—	848,021	921,916	24,668	7,050	277	—	—	—
3	33,481	594,779	297,570	17,306	741	—	—	—	—
4	240,750	60,268	17,499	5,937	158				
Totals	274,231	1,611,960	1,341,085	47,966	7,949	277	—	—	—
1977									
1	—	123,384	231,520	15,203	4,963	—	—	—	—
2	—	343,760	1,188,714	49,055	9,146	1,236	101	—	—
3	4,341	394,103	620,469	14,608	3,473	169	12	—	—
4	480,282	143,291	41,062	4,594	220	—	—		—
Totals	484,623	1,004,538	2,018,765	83,460	17,802	1,405	113	—	—
1978									
1	—	30,019	124,086	22,954	376	—	—	—	—
2	—	250,559	1,209,137	180,411	18,159	2,281	—	—	—
3	131,037	270,301	295,198	42,611	5,721	641	—	—	—
4	326,376	113,209	42,490	12,145	6,930	555	—	—	—
Totals	457,413	664,088	1,670,911	258,121	31,186	3,477	—	—	—
1979									
1	—	15,628	144,138	5,877	—	—	—	—	—
2	1,223	141,879	1,075,501	71,567	12,619	1,325	—	—	—
3	15,012	385,538	339,901	42,980	6,671	145	93	—	—
4	1,476,227	80,091	43,745	7,502	2,468		—	—	—
Totals	1,492,462	623,136	1,603,285	127,926	21,758	1,470	93	—	—
1980									
1	—	127,442	84,282	13,128	205	—	—	—	—
2	—	349,624	1,020,059	145,881	36,675	6,817	574	—	
3	7,967	738,873	323,598	47,392	22,431	4,998	398	—	—
4	80,323	262,119	30,295	16,311	9,917	2,541	466	—	—
Totals	88,290	1,478,058	1,458,234	222,712	69,228	14,356	1,438	—	—

Appendix Table 14 (Cont'd)

Coastwide estimated numbers of Atlantic menhaden (10^3) caught by purse seine vessels by age, quarter, and year, 1965-84 (quarters were summed before rounding to thousands).

	Age (yr)								
Quarter	0	1	2	3	4	5	6	7	8-10
1981									
1	—	8,180	141,578	42,447	1,822	596	—	—	—
2	558	208,558	1,192,587	139,655	40,144	13,444	1,047	—	—
3	193,442	308,693	426,211	40,099	5,505	1,333	227	—	—
4	993,574	173,234	51,086	—	—	—	—	—	—
Totals	1,187,574	698,665	1,811,462	222,201	47,471	15,373	1,274	—	—
1982									
1	—	25,961	204,151	76,186	279	93	—	—	—
2	—	364,514	1,173,062	228,657	10,255	4,800	528	321	—
3	12,411	398,258	309,170	60,273	2,741	—	—	—	—
4	101,697	130,704	53,167	14,549	3,053	886	—	—	—
Totals	114,108	919,437	1,739,550	379,665	16,328	5,779	528	321	—
1983									
1	—	8,949	219,438	2,705	610	—	—	—	—
2	—	180,174	1,459,857	56,347	12,459	1,661	229	—	—
3	222,732	141,717	553,845	20,111	6,874	2,049	—	—	—
4	741,683	186,377	59,924	35,184	27,426	1,298	—	—	462
Totals	964,415	517,217	2,293,064	114,347	47,369	5,008	229	—	462
1984									
1	—	12,656	59,083	8,249	—	—	—	—	—
2	5,652	339,075	539,480	165,027	19,369	5,707	140	—	—
3	279,864	211,382	278,884	65,177	7,599	2,330	—	—	—
4	1,008,707	461,052	14,642	33,048	23,371	7,170	372	—	—
Totals	1,294,223	1,024,165	892,089	271,501	50,339	15,207	512	—	—

GPO 591-131/81004

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